Using Calculators to Develop Problem-Solving Skills in Fifth Graders

An Honors Thesis (HONRS 499)

by

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Abstract

This action research project was conducted to examine the effects of calculator use in the development of problem-solving skills in a class of fifth grade students in an urban classroom. This project was intended to support and further clarify the research already available on the topic of calculator use and problem solving. During the investigation, students completed a pre and post questionnaire, which consisted of seven statements relating to calculators and word problems. Children also participated in nine problem-solving activities. These activities were specifically designed to be completed by using a calculator. Each activity focused on one of eight problem strategies: guess and check, use or look for a pattern, use or make a table, make an organized list, make it simpler, use logical reasoning, make a picture or diagram, and work backwards. Written observations were taken of the students by the investigator. Three methods of data collection were used: pre and postquestionnaires, problem-solving activity sheets, and student observations. After the investigation was complete, the three kinds of data were analyzed for similarities and differences across individuals and groups. Each kind of data was separated by gender, as well as by ability level.

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Statement of the Problem

In the field of mathematics education, there are conflicting views on the subject of calculator use in elementary classrooms. Some critics argue that calculator use is damaging to mathematics students. They claim that using a calculator urges children to try random computations without any real understanding of the mathematics behind the problem (Starr, 2002). Calculator opponents are worried that frequent calculator use by children will eventually produce adults who are dependent on calculators to perform even basic tasks.

However, many educators believe that calculators do have a place in the classroom. Calculator proponents claim that by using calculators, students develop better number sense, are able to study more complex mathematical concepts, and are able to spend more time understanding problems and concepts without getting bogged down by tedious calculations (Starr, 2002). Numerous studies have shown that students are more effective in selecting and using appropriate problem-solving strategies and are more confident and enthusiastic when allowed to use calculators in solving math problems (Hembree & Dessart, 1986; Reys & Reys, 1987).

In the May/June issue of *Mathematics Education Dialogues*, readers were asked to share their views on calculator use in the classroom. Three hundred sixty educational professionals responded with their opinions and information on calculator use in their schools. All those who responded agreed that calculators should be used in schools. However, many noted that in order for calculators to be used successfully, both teachers and students need proper training and instruction. For the most part, the educators who responded all agreed "calculators are powerful tools when used appropriately and that they should be used in all grades where problem solving is the main focus" (Ballheim, 1999, p. 4).

Many educators currently agree that after computational skills are mastered, students should be able to use calculators to check computation and complete problem-solving exercises (Flores, 2002). However, there are some who believe that calculators should play a fundamental role in the education of our children. They believe that calculators can be used to develop concepts and computational skills. There is much research that supports this view as well.

In 1986, Hembree and Dessart conducted a meta-analysis of the results of 88 studies on calculator use in precollege students. In each study, the test group used calculators and the control group had no access to calculators. It was concluded that student achievement was not hindered by the use of calculators and that student attitudes and self-concepts improved considerably. In another meta-analysis of 24 research studies on calculator use, Smith (1997) showed that the students' conceptual knowledge increased in all grades. This positive effect was significantly evident in students in third grade, seventh through tenth grades, and twelfth grade. These findings support the argument for the use of calculators in all areas of mathematics education.

The National Council of Teachers of Mathematics (NCTM) has taken a stance in favor of the use of calculators by all children in grades K-12. In its *Principles and Standards for School Mathematics*, NCTM (2000) states:

- Today, the calculator is a commonly used computational tool outside the classroom, and the environment inside the classroom should reflect this reality. (p.33)
- Electronic technologies – calculators and computers – are essential tools for teaching, learning, and doing mathematics.... When technological tools are available, students can focus on decision making, reflection, reasoning, and problem solving. (p. 24)
- As students encounter problem situations in which computations are more cumbersome or tedious, they should be encouraged to use calculators to aid in problem solving. (pp. 87-88)
- Guided work with calculators can enable students to explore number and pattern, focus on problem-solving processes, and investigate realistic applications. (p. 77)

According to NCTM (2000), problem solving is the foundation of the mathematics that we teach in schools today. Our goal as educators should be for "all students to become increasingly able and willing to engage with and solve problems" (NCTM, 2000, p. 181). Likewise, Indiana Academic Standard 5.7 states that fifth grade students should be learning how to approach problems, explain their reasoning, and check their answers. (Indiana Department of Education, 2002) This skill should be practiced in all areas of mathematics that are taught in this grade.

Another professional organization that supports the use of technology in the classroom is the International Society for Technology in Education (ISTE).

The ISTE has developed National Educational Technology Standards for students and for teachers. According to these standards, by the time students complete grade five, they should be able to use calculators and other technology resources for problem solving (ISTE 2002).

Calculators can be powerful tools in the study of mathematics, particularly in the area of problem solving. This action research project was conducted to examine the effects of calculator use in the development of problem-solving skills in a class of fifth grade students. It was intended to support the research already available on the topic of calculator use and problem solving.

Methods and Procedures

The investigation took place in a fifth grade classroom in T.C. Steele Elementary School #98. The school is located in the city of Indianapolis and is part of the Indianapolis Public School system. Preschool through grade five are housed in the building, with a total enrollment of 352 students for the 2002-2003 school year. The school is on a traditional schedule and follows a "Back to Basics" philosophy in its curriculum. T. C. Steele is a Title 1 school and also on the Universal Free Lunch program. Fifty percent of T. C. Steele third grade students passed the Indiana Statewide Test of Educational Progress (ISTEP+) in the 2001-2002 school year. This school is also a Professional Development School in partnership with Ball State University. The fifth grade at T. C. Steele is departmentalized for some subjects. Students are grouped by ability and switch teachers for math, reading, science and social studies. The students chosen to participate in this study came from the "higher ability" math class.

The investigation began in August, shortly after the 2002-2003 school year began. As required by both the Ball State University Office of Academic Research and Indianapolis Public Schools, an informed consent form (see Appendix A) was sent home with each student at the beginning of the semester. This form, sent along with a letter of explanation from the classroom teacher, gave an overview of the study and required both parent and student signatures. Out of the 26 students in the math class, 25 students agreed to participate by returning signed informed consent forms. The investigation began after the informed consent forms had been returned by all participating students.

The students were given a questionnaire, which consisted of seven statements relating to calculators and word problems (see Appendix B). These statements were designed to give insight into students' knowledge and perceptions of calculators and their uses. The students were asked to respond to each statement with an honest answer. It was stressed by the investigator that there were no wrong answers and that they would not receive a grade based on anything they wrote on this questionnaire. While students were given as much time as needed, many completed the questionnaire in 5-10 minutes.

Two days after completing the questionnaire, each student was assigned a Texas Instruments Math Explorer calculator to use for the duration of the investigation. This type of calculator has several unique features, including one that allows the user to perform operations with fractions and mixed numerals and express division results as quotients with remainders. These calculators were made available to students for use during activities relating to this investigation. Students did not use the calculators at any other time during the day. After receiving the calculators for the first time, the students were given a "tour" of the calculator and its features. During a 30-minute lesson, they were taught how to perform simple operations on the calculator, how to use the memory functions and the constant features, and how to read the display.

I decided to use activities from the *Problem Solver with Calculators* by Terrence G. Coburn, Shirley Hoogeboom, and Judy Goodnow. This teacher's resource book contains 50 word problems written for children in grades four through six. These problems are most efficiently solved with the help of a calculator. The *Problem Solver with Calculators* focuses on eight problem-solving strategies. These strategies include: guess and check, use or look for a pattern, use or make a table, make an organized list, make it simpler, use logical reasoning, make a picture or diagram, and work backwards. Because these strategies also appear in the students' math textbooks, these activities were easily integrated into daily lessons.

The problem-solving strategies were sorted by difficulty and the activities were presented in this order of increasing difficulty: guess and check, use or look for a pattern, use or make a table, use logical reasoning, make a picture or diagram, make an organized list, make the problem simpler, and work backwards. Due to time constraints and other circumstances beyond the control of the investigator, the students completed only nine of the 16 prepared activities. The class was given the opportunity to do more activities for a few days during recess. Five students chose to do this and were able to complete three more activities than the rest of the class.

At the conclusion of the investigation, students were given a postquestionnaire identical to the one that they completed in August. Students were again encouraged to take their time and give honest, complete answers. They were also told that a grade would not be taken on this questionnaire.

After the investigation was complete, the three kinds of data were analyzed for similarities and differences across individuals and groups. Each kind of data was separated by gender, as well as by ability level. Students were placed into one of the two ability levels based on the judgment of the investigator.

In deciding placement, the investigator looked at report card grades, grades on classwork and homework, and classroom participation.

The pre and postquestionnaires were collected and studied for patterns and changes in students' attitudes towards calculators and problem solving. Statements given by students were interpreted and marked as a positive or negative response, based on wording and tone.

Data also came from activity sheets completed by the students. Each student was assigned a folder, which contained blank activity sheets. At the end of the investigation, the folders were collected. Two factors were used in analyzing student activity sheets: how effectively children used calculators to solve problems and how correctly they solved problems. It should be noted that any student work from these activities was used only for this study and not for grading purposes. Examples of student work on similar word problems (solved without calculators) were used as a tool for comparison.

The third method of data collection consisted of observations made by the investigator. The investigator observed and recorded comments made by the students during the activities, as well as relevant comments made throughout the day. All observations were recorded on a standard form (see Appendix C). During the activities, student behavior was also observed and recorded. Behaviors particularly noted by the investigator include frequency of calculator use and frequency of questions to the teacher.

Data Analysis

The data, gathered throughout the investigation, were collected and analyzed to determine the effects on calculator use on the problem-solving strategies of this group of fifth grade students. Three methods of data collection were used: pre and postquestionnaires, problem-solving activity sheets, and student observations. Each method of data collection was analyzed by itself and then results were compiled.

Pre and Postquestionnaires

The questionnaires provided valuable insight into the students' opinions and thoughts about calculators and their uses. In general, the postquestionnaire showed that students felt they gained knowledge about calculators. In response to the statement "Tell me what you know about calculators" on the pre-questionnaire, students made comments such as "They make things go quicker" and "They help you do math." On the postquestionnaire, the same students gave these more detailed comments: "They can do fractions and get remainders" and "You can add, subtract, multiply, [sic] divide any numbers." Many of the students made similar remarks.

The majority of students appeared to change their attitudes towards story problems as well. When asked how they felt about story problems, students responded on the prequestionnaire with statements such as: "I don't like them," "They are too hard," and "Not fun." However, these comments were made on the postquestionnaire: "I like them now," "They're interesting," and "I feel great about them." It should be noted that not all students showed such a considerable positive change in attitude towards story problems on these questionnaires. However, no students showed a negative change in attitude towards story problems.

The individual responses were divided by gender and analyzed for patterns. On the prequestionnaires, one pattern quickly became apparent. In response to the prompt, "Tell me how you feel about story problems," the majority of negative comments came from female students. Seventy-three percent of girls responded negatively to this prompt, while only 57% of boys responded in the same way. On the postquestionnaires, increased numbers of both girls and boys responded positively towards story problems. However, there were still more negative responses from the female students than from the male students.

When students were asked to tell what they did not understand about calculators, male and female students gave varying responses on both questionnaires. Boys most often wrote comments such as, "Nothing," "Everything is easy," and "I understand everything." They seemed more confident of their knowledge of calculators and how they work. They also were more likely to ask technical questions, like "How does the solar power work?" or "How does it know to shut itself off?" The girls seemed to have different concerns. They wondered about different symbols and keys that we did not discuss in class. One girl asked, "Why does it matter what order we put the numbers in?" They seemed more inquisitive about the actual mathematical operations. According to the American Association of University Women

(AAUW), "Girls have developed an appreciably different relationship to technology than boys… and technology may exacerbate rather than diminish inequalities by gender as it becomes more integral to the K-12 classroom" (1999, p. 27). More boys have and use technological games, tools, and toys. They are more aware of technology and how it works. Girls, like the ones in this investigation, do not usually show as much of an interest in technology. This might explain why these fifth grade girls asked questions about mathematics and not technology.

The questionnaires were also divided into two categories based on student ability. As previously noted, the participating students were grouped based on the investigator's knowledge of each student's performance, grades and classroom participation. When students were asked how they felt about story problems, 43% of students in the lower ability group responded positively on the prequestionnaire. Seventy-nine percent of the same students responded positively on the postquestionnaire. These data show a change in attitude towards story problems for some of the lower ability students. However, the change in attitude was even greater for the students in the higher ability group. Only 20% of these students gave positive responses to this prompt on the prequestionnaire, while 70% responded positively on the postquestionnaire.

When the questionnaire responses were grouped by student ability, another interesting pattern emerged. In one prompt, students were asked to write why they would use a calculator. The responses to this particular prompt were very similar on both the prequestionnaire and the postquestionnaire. Many of the students in the higher ability group wrote responses such as, "It is easier," "It helps you get your answer quicker," and "It would take too long to do it on paper." Their responses seemed to center around speed and ease of solving the problem. However, most students in the lower ability group submitted responses relating to the difficulty of the problem, such as, "The problems might be hard," and "It can get confusing without a calculator."

In response to "Tell me what you do not quite understand about calculators," some students in both ability groups said that they understood everything. About the same amount of students on both ability groups had questions or things that they did not understand. Although it might have been expected that students in the higher ability group would have fewer questions or understand less, this was not the case with this set of students.

Problem-Solving Activity Sheets

All students completed at least nine calculator activities. The calculator activities tested these six different problem-solving strategies:

Activity 1 – Guess and check
Activity 2 – Guess and check
Activity 3 – Make a pattern
Activity 4 – Make a pattern
Activity 5 – Make a table
Activity 6 – Make a picture
Activity 7 – Use logical reasoning
Activity 8 – Make a picture
Activity 9 – Make an organized list

These activities were analyzed to see how effectively children used the calculators to solve problems and how correctly they solved the problems. The table below shows the percentage of participating students who solved each activity correctly. These data show no distinct increase or decrease in scores.

This inconsistency might be attributed to the varying difficulties of the activities. A more detailed table showing each student's individual scores can be found in Appendix D.

Activity	1	2	3	4	5	6	7	8	9
% Correct	80	72	64	84	88	76	80	84	88

Students were allowed to work with classmates on these activities and received help from the teacher when asked. The scores shown in the table above may not necessarily be reflective of what knowledge they alone possess. However, the investigator believes that students learn better when able to work with others, and the ultimate goal of this investigation was to promote learning.

A few of the calculator activities repeated the same problem-solving strategy. These results were examined to see if student performance had increased the second time the strategy was used. Both Activities One and Two involved using the "Guess and check" strategy. Eighty percent of the students correctly solved the first of these activities. However, only 72% of students correctly solved the second activity. A noticeably different trend was seen in the activities relating to the "Make a pattern" and "Make a picture" strategies. Each time these strategies were repeated, student scores increased 20% and 8%, respectively. These data reinforce the use of a teaching method that most educators already practice in their classrooms. Students benefit from repeated practice of any concept they are learning.

Ten of the 25 students (40%) completed every activity correctly, giving them a perfect score. Eighty percent of the students would have passed if they had been given a grade based on the traditional scale, where a score below 60% is failing.

Student data from the activity sheets were divided according to gender and these results were analyzed (see Appendix E). These tables show a distinct difference between the performance of the boys and the performance of the girls on the activities in this investigation. The boys performed better than the girls on all but two of the calculator activities. On average, the females correctly answered 77% of the activities. The males scored slightly better, correctly answering 83% of all activities. Fifty percent of the boys correctly completed every activity, giving them a perfect score. However, only 27% of the girls scored 100%.

There appears to be no improvement in girls' scores over the course of the investigation. However, neither do the scores decrease. They show no clear pattern. On the final activity, the girls scored their highest average score of 90%. This activity was related to the "Make an organized list" problem-solving strategy. They scored lowest in Activities Three and Six, which used "Make a pattern" and "Make a picture," respectively. However, both of these strategies were used again in later calculator activities. Each time, the girls' average score went up considerably, from a 54% to an 81%.

Like the girls' scores, the boys' scores showed no indication of progression or regression. The boys performed exceptionally well on Activity Five. However, Activity Five was one of the lowest scoring activities for the girls. This discrepancy also occurred with Activity Six. The girls' average score was

54%, while the boys scored an average of 93%. Activities Five and Six used the "Make a table" and "Make a pattern" strategies, respectively. Both of these strategies involved making visual representations of data. These data suggest that boys are more visual learners. While research results widely vary on the topic of learning styles and gender, some propose that men are more visual thinkers and tend to prefer ideas in picture-form (Sadler-Smith, 1999).

The boys' lowest average score on any of the nine activities was 71% on Activity Two and Activity Three. This is rather interesting because Activity Two was the second time the students were exposed to problems involving the "Guess and check" strategy. Yet, their average score decreased.

Student data were also divided according to ability level and analyzed for similarities and differences (see Appendix F). Although there were an equal number of girls and boys in the lower ability group, 64% of the higher ability group was composed of boys. As was expected, many of the perfect scores belonged to students in the higher ability group. However, this was not always the case. Student K, who usually does quite well on his classwork and homework assignments, performed poorly on these activities. Other exceptions are Students I and W, both of whom earned perfect scores on their activities and are in the lower ability group. There could be many explanations for this irregularity. These students might excel at story problems. They may have benefited greatly from using the calculator. Or they may have just been working with another student.

In November, students were given a pair of story problems to complete without the use of a calculator (see Appendix G). The purpose of this assignment was to see if students understood the mathematical concepts behind the activities they were completing. The problems in this assignment were similar in difficulty to the calculator activities. The students had practice with the "Make a picture" problem-solving strategy needed to complete these two problems. These problems were also designed so that they could be completed easily without a calculator. Scores from these problems were slightly lower than scores taken from the activities completed with calculators. On average, 79% of students answered the calculator activities correctly, while only 72% of students correctly solved the problems in this set. Student scores were higher when they used calculators.

Student Observations

Observations were taken throughout the investigation in order to gain further insight on the project. It was observed by the investigator that the students were all generally excited and very willing to participate in this project. They were curious about what they would be learning and about what they would be doing with the calculators. They liked having the calculators in their hands and seemed to enjoy the challenge of learning how to use them. On two occasions, the students even willingly stayed after class a few minutes to finish an activity. As previously mentioned, some students wanted to stay in during their recess time to work on more activities.

Observations taken by the investigator revealed that the activities might have been too difficult for the students. Most students solved the problems correctly, but only after considerable help from the teacher and/or fellow classmates. Tally marks were used to keep track of the number of times students asked the teacher for help. Based on this observation, students who asked for assistance were far more likely to answer the problem correctly. In general, students either asked for help very often, or not at all. There were few students who fell in between.

It quickly became apparent that many of the participating students did not completely understand certain mathematical concepts used in the activities. In the third activity for example, students were given a story problem about a man and a fish. The man goes out to a certain place on the lake every 168 hours, and the fish feeds at the place every 88 hours. Students were asked to determine how many days will pass before the man has a chance to catch the fish. This activity involved using the constant function on the calculator to find multiples of 168 and 88. Ultimately, students needed to find the least common multiple of the two numbers. When the investigator asked for the definition of least common multiple, four students raised their hands. Individually, random students were asked to describe why they were using the constant function and what they were finding. Seven of the 12 students who were asked were unable to explain what they were doing. They only knew that the paper told them to use certain keystrokes to find a series of numbers. The other students could explain the operation to varying degrees. Situations similar to this one were observed by the investigator several times throughout the course of the study.

When the student observation data were grouped according to gender, a few patterns appeared. The male students were more likely to ask for help from the teacher. Female students asked for help too, but it was observed that they were more likely to attempt to get assistance from a classmate first. The girls were also more likely to choose to work with a partner once that option was given. The girls were also usually the ones to ask if they could work with a classmate. Students were always allowed to work together, but were encouraged to try the problem on their own first. While all students seemed enthusiastic about being able to use the calculators, it was noted by the investigator that on a few occasions, boys asked to use their calculators on other assignments during math class. They also seemed more excited when it was announced that we would be doing a calculator activity in class.

The observation data were also divided by ability level into two separate groups. Students from the higher ability group asked for assistance on an activity almost twice as often as students in the lower ability group. This may or may not be reflected in their scores on the calculator activities. It was not clear from the data whether students in either ability group preferred to work alone or with a classmate.

Conclusions

Considerable research has shown that calculators as tools can be effective in building confidence and self-esteem in mathematics students (Hembree & Dessart, 1986; Finley, 1992; Reys & Reys, 1987). Quality educators realize that when students are confident in their abilities, their performance is likely to improve. The findings presented in this paper support that research. While the prequestionnaires revealed negative attitudes towards story problems, many of the participating students changed their attitudes over the course of the investigation.

Besides helping to change attitudes, using calculators in the classroom can make story problems more exciting and realistic. Teachers can create story problems using data relevant to their students, without concern over the size or complexity of the numbers. The use of realistic data is motivational and helps children see connections between school mathematics and the mathematics used in the world (Hembree &Dessart, 1986).

In her article in *Mathematics Education Dialogues*, Charlene Morrow suggests that structured interactions with calculators are needed for boys and girls alike (1999). She discusses the challenges that girls face with the increased use of technology in the classroom. Morrow describes a unique program at Mount Holyoke College that is designed to empower females to be technology users. Since males in our society tend to naturally have and use more technological toys and tools, opportunities must be made for all students to succeed with technology (1999). The results of this investigation illustrate a need for this type of awareness to familiarize girls with calculators and other types of technology. Many differences were found between the fifth grade boys and girls in relation to problem solving and calculators. Girls scored lower in problem solving, had different views of technology, and required different strategies to be successful. On most of the activity sheets, the boys performed better than the girls. In general, boys' scores were higher than girls' scores in many different areas. As educators, we need to pay attention to these gender disparities and intentionally work to help all children, boys and girls alike, reach their potential. It is essential that we purposefully structure activities to allow for equal opportunities for learning.

One of the primary arguments of calculator critics is that by using calculators, students will not learn fundamental mathematical concepts. However, over 100 studies have confirmed that calculators do not keep children from learning basic mathematics skills (Jehlenelewski, 2001). While calculators do not keep students from learning basic skills, teachers must make sure students have a solid understanding of the skills when they choose to use calculator activities.

The third activity that was observed by the investigator, described in detail in the previous section, illustrates this valuable consideration in the use of calculators in mathematics education. In the situation described, many students did not fully understand the concepts behind the operations that they were performing. The students did not possess enough of an understanding of the concepts to successfully complete the activity. Elementary teachers who use calculators in their classrooms must be sure that their students understand the numbers they are putting into the calculator and the values that they are receiving. As a sixth grade teacher points out, "People who lack good grammar skills can be misled by the corrections offered by the computer grammar checkers. People who lack good math skills (including interpreting results) can be misled by what their calculators tell them. Calculators must be used thoughtfully" (Ballheim, 1999).

If I were to replicate this investigation, there are certain aspects that I would change. First, there simply was not enough time to complete all the intended activities in this investigation. The design of this project did not allow the activities to be spread out over a longer period of time, or completed in several intense sessions. An increased number of completed activities would have given the investigator more data to analyze, possibly providing more conclusive results.

Second, in this research project, open-ended questions were chosen for the pre and postquestionnaire to allow the students to express exactly how they felt, without having to translate their feelings into values. In future studies it would be valuable to include some objective-type questions on the questionnaires. Changes in student attitudes could have been more concretely measured if the questions were objective and not open-ended. To note changes in student attitudes over the course of the investigation, a valuable step might also be to record and transcribe classroom conversations between students during the actual activities. A single person took all the observations in this investigation, therefore it was physically impossible to hear and witness every comment made by 25 students. By using a video camera or audiotape recorder, more comments and behaviors could be observed.

Further research is needed in the area of calculators and problem-solving skills in elementary students. One area of research would be to elaborate on this study and provide more concrete evidence by including a pre and posttest of student knowledge relating to problem-solving skills in word problems. This would allow for more substantial evidence of increased problem-solving skills because of the use of calculators.

In addition, further research is needed to determine a connection between gender and calculator usage in problem-solving activities. Surprising results from this investigation indicated that the boys performed better than the girls in almost all areas. These findings may be specific to this group of participating students. The findings may have also stemmed from the particular activities used in the investigation. However, more research is necessary to come to a conclusion.

Additional research is also needed in the area of gender differences on problem-solving strategies that involved visual representation. In this investigation, the boys performed exceptionally well on activities involving strategies such as "Draw a picture" and "Make a table." This conclusion also warrants further research and investigation. Would the same findings hold true for other groups of students? Are there other problem-solving strategies at which girls would excel?

While the activities in this investigation were presented by someone with training in integrating calculators into the classroom, the majority of elementary teachers today do not have such experience. Many educators are unaware of the uses and learning potential of calculators. If elementary school teachers are expected to make use of calculators and other forms of technology in their classroom, then sufficient professional development opportunities must be made available.

The findings from this study support the assertion that calculator use in the classroom does not hinder student performance on problem-solving activities. Calculator use may even improve student performance and attitudes towards problem-solving activities. Since professional organizations such as the National Council of Teachers of Mathematics, the Indiana Professional Standards Board, and the International Society for Technology in Education promote the integration of calculators in elementary mathematics classrooms, all educators should consider how to integrate them into their classrooms to best enhance mathematics instruction and benefit their students, particularly in the area of problem solving.

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Appendix A:

Informed Consent Form

Using Calculators to Develop Problem-Solving Skills in Fifth Graders

The purpose of this research study is to look at the effects of calculator use in the development of problem-solving skills in a class of fifth grade students.

As a subject, your student will be asked to complete a questionnaire at the beginning of the study. The questionnaire is designed to give insight into their knowledge and perceptions of calculators. This same questionnaire will be given at the end of the study. The researcher will also lead the students in 16-20 problem-solving activities over the course of the semester, which involve the use of calculators. During the semester, your student will be observed in everyday classroom activities and notes will be taken regarding application of learned strategies. At the end of the semester, the questionnaires, observation notes, and written samples obtained from the activities will be compiled and written up.

There are no risks associated with this research study. The benefits of this research are important. First, the students will learn new problem-solving strategies while participating in the activities. The students will also have the opportunity to learn more about how a calculator can be used in these problem-solving activities. This research will give a better understanding of how other educators can use calculators to develop these skills with their students.

Participation in this research is completely voluntary and will not affect the student's grades or records. You are free to remove your student from the study at any time for any reason without any penalty or prejudice from the investigator or classroom teacher. All records and results will be kept confidential. The investigator will use pseudonyms instead of the children's real names. All records will be kept locked away when not in the possession of the researcher to prevent breaches of confidentiality.

For your student's rights as a research subject, the following person may be contacted: Ms. Sandra Smith, Coordinator of Research Compliance, Office of Academic Research and Sponsored Programs, Ball State University, Muncie, IN 47306, (765) 285-1600.

* *

I give my consent for my child, ________________________ to participate in this research study entitled "**Using Calculators to Develop Problem-Solving Skills in Fifth Graders**." I have read the description of the study and understand what it says. Any questions I had were answered to my satisfaction. I have read this description of the study and give my consent for my child named above to participate. I understand that I will receive a copy of this consent form to keep for future reference.

______________________________ ____________________

Parent Signature Date

This study has been fully explained to me and I understand what I have to do. I, ____________________, agree to participate in this project entitled, "**Using Calculators to Develop Problem-Solving Skills in Fifth Graders**."

______________________________ ____________________

Child's Assent Line Date

PI: Martha Christopher
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Phone: (219) 406-0923

Faculty Advisor: Dr. Annette Leitze
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Appendix B:

Questionnaire

Name ____________________________

Tell me what you know about calculators.

Tell me the best thing you can do on a calculator.

Tell me how you feel about story problems.

Tell me the sort of problems you would do on a calculator.

Tell me why you would use a calculator for those problems.

Tell me what you would like to be able to do on a calculator.

Tell me what you do not quite understand about calculators.

Appendix C:

Observation Form

Observations

A					
B					
C					
D					
E					
F					
G					

Appendix D:

Activity Sheet Scores

Activity Sheet Scores

Student	Activity 1	Activity 2	Activity 3	Activity 4	Activity 5	Activity 6	Activity 7	Activity 8	Activity 9	% Correct
A	+	+	+	+	+	+	+	+	+	100%
B	+	+	+	+	+	+	+	+	+	100%
G	+	+	+	+	+	+	+	+	+	100%
I	+	+	+	+	+	+	+	+	+	100%
J	+	+	+	+	+	+	+	+	+	100%
L	+	+	+	+	+	+	+	+	+	100%
M	+	+	+	+	+	+	+	+	+	100%
Q	+	+	+	+	+	+	+	+	+	100%
U	+	+	+	+	+	+	+	+	+	100%
W	+	+	+	+	+	+	+	+	+	100%
C	+	+	+	+	--	+	+	+	+	89%
N	--	+	+	+	+	+	+	+	+	89%
O	+	+	+	+	+	+	+	--	+	89%
X	+	+	+	+	+	+	+	--	+	89%
F	+	--	--	+	+	+	+	+	+	78%
S	+	+	--	+	+	+	+	+	--	78%
D	+	+	--	+	+	--	+	--	+	67%
P	--	--	--	+	+	--	--	+	+	67%
T	+	+	--	+	--	--	+	+	+	67%
Y	+	--	--	--	+	+	+	+	+	67%
K	+	--	--	+	+	+	--	--	+	56%
R	+	--	+	--	--	--	+	+	+	56%
E	--	--	+	--	+	+	--	+	--	44%
V	--	--	--	+	+	--	--	+	+	44%
H	--	+	--	--	+	--	--	+	--	33%
% Correct	80%	72%	64%	84%	88%	76%	80%	84%	88%	

Average Student Score: 79.2%

Appendix E:

Activity Sheet Scores by Gender

Activity Sheet Scores by Gender

Girls

	Activity 1	Activity 2	Activity 3	Activity 4	Activity 5	Activity 6	Activity 7	Activity 8	Activity 9	
A	+	+	+	+	+	+	+	+	+	100%
C	+	+	+	+	--	+	+	+	+	89%
D	+	+	--	+	+	--	+	--	+	67%
F	+	--	--	+	+	+	+	+	+	78%
H	--	+	--	--	+	--	--	+	--	33%
L	+	+	+	+	+	+	+	+	+	100%
O	+	+	+	+	+	+	+	--	+	89%
P	--	--	--	+	+	--	--	+	+	67%
Q	+	+	+	+	+	+	+	+	+	100%
R	+	--	+	--	--	--	+	+	+	56%
T	+	+	--	+	--	--	+	+	+	67%
	81%	72%	54%	81%	72%	54%	81%	81%	90%	76.91%

Boys

	Activity 1	Activity 2	Activity 3	Activity 4	Activity 5	Activity 6	Activity 7	Activity 8	Activity 9	
B	+	+	+	+	+	+	+	+	+	100%
E	--	--	+	--	+	+	--	+	--	44%
G	+	+	+	+	+	+	+	+	+	100%
I	+	+	+	+	+	+	+	+	+	100%
J	+	+	+	+	+	+	+	+	+	100%
K	+	--	--	+	+	+	--	--	+	56%
M	+	+	+	+	+	+	+	+	+	100%
N	--	+	+	+	+	+	+	+	+	89%
S	+	+	--	+	+	+	+	+	--	78%
U	+	+	+	+	+	+	+	+	+	100%
V	--	--	--	+	+	--	--	+	+	44%
W	+	+	+	+	+	+	+	+	+	100%
X	+	+	+	+	+	+	+	--	+	89%
Y	+	--	--	--	+	+	+	+	+	67%
	79%	71%	71%	86%	100%	93%	79%	86%	86%	83.35%

Appendix F:

Activity Sheet Scores by Ability Level

Higher Ability

	Activity 1	Activity 2	Activity 3	Activity 4	Activity 5	Activity 6	Activity 7	Activity 8	Activity 9	
A	+	+	+	+	+	+	+	+	+	100%
B	+	+	+	+	+	+	+	+	+	100%
G	+	+	+	+	+	+	+	+	+	100%
J	+	+	+	+	+	+	+	+	+	100%
K	+	--	--	+	+	+	--	--	+	56%
L	+	+	+	+	+	+	+	+	+	100%
M	+	+	+	+	+	+	+	+	+	100%
N	--	+	+	+	+	+	+	+	+	89%
O	+	+	+	+	+	+	+	--	+	89%
Q	+	+	+	+	+	+	+	+	+	100%
U	+	+	+	+	+	+	+	+	+	100%

Lower Ability

	Activity 1	Activity 2	Activity 3	Activity 4	Activity 5	Activity 6	Activity 7	Activity 8	Activity 9	
C	+	+	+	+	--	+	+	+	+	89%
D	+	+	--	+	+	--	+	--	+	67%
E	--	--	+	--	+	+	--	+	--	44%
F	+	--	--	+	+	+	+	+	+	78%
H	--	+	--	--	+	--	--	+	--	33%
I	+	+	+	+	+	+	+	+	+	100%
P	--	--	--	+	+	--	--	+	+	67%
R	+	--	+	--	--	--	+	+	+	56%
S	+	+	--	+	+	+	+	+	--	78%
T	+	+	--	+	--	--	+	+	+	67%
V	--	--	--	+	+	--	--	+	+	44%
W	+	+	+	+	+	+	+	+	+	100%
X	+	+	+	+	+	+	+	--	+	89%
Y	+	--	--	--	+	+	+	+	+	67%

Appendix G:

Story Problem Set

The True Story of the Three Little Pigs

A poll was taken in the local newspaper, *The Daily Pig*, to see what the readers thought should be Alexander T. Wolf's punishment for his crime. Of the 100 readers who responded, 75 believed that the wolf should be forced to do community service by volunteering at Piglet Elementary School. 85 readers thought that A. T. Wolf should have to pay for the damage he did to the three houses, and 60 readers said that he should have to do community service and pay for the houses. How many readers voted only for the community service, and how many voted only for the wolf to pay?

In order to get out of prison, Alexander T. Wolf must tell his story to the judge in court. Goldilocks, the Evil Stepmother, and Rumpelstiltskin also have trials today. The police officers take him, along with the three other criminals to the big, 15-story courthouse downtown on the day of his trial. First they drop off the Evil Stepmother at the courtroom that is two floors below the top of the building. The police officers deliver Goldilocks to the courtroom six floors above the floor where they take Rumpelstiltskin. Finally, they take Alexander T. Wolf to his trial that is nine floors below the Evil Stepmother and one floor above Rumpelstiltskin. What is the number of each floor where the criminals are having their trials?